Amusement Park Injuries and Deaths

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Media coverage of amusement park injuries has increased over the past several years, raising concern that amusement rides may be dangerous. Amusement park fatalities and increases in reported injuries have prompted proposed legislation to regulate the industry. Since 1979, the medical literature has published reports of 4 subdural hematomas, 4 internal carotid artery dissections, 2 vertebral artery dissections, 2 subarachnoid hemorrhages, 1 intraparenchymal hemorrhage, and 1 carotid artery thrombosis with stroke, all related to roller coaster rides. In this article, we review reports of amusement park injuries in the medical literature and Consumer Product Safety Commission data on the overall risk of injury. We also discuss the physics and the physiologic effects of roller coasters that may influence the type and severity of injuries. Although the risk of injury is low, emergency physicians are advised to include participation on thrill rides as part of their history, particularly when evaluating patients presenting with neurologic symptoms.

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INTRODUCTION

The US Amusement and Theme Park Industry continues to grow in popularity. Amusement parks reported a record $9.1 billion in revenue during 1999. In 1999, the 450 fixed-site amusement parks in the United States accommodated approximately 309 million visitors from around the world.[1] Amusement parks owe their popularity, at least in part, to roller coasters, which date back to the 15th-century Russian mountains (Table 1).[1,2] Roller coasters continue to set new height and speed records as engineers attempt to outdo each other by building the fastest, most thrilling ride in this increasingly competitive industry (Table 2).[3,4]

Amusement park injuries and mishaps have long been considered newsworthy events, but stories have become more common in the last several years. A string of fatal amusement park accidents during a 6-day period in August of 1999 led many to question the safety of amusement park rides and prompted legislative attempts to regulate the industry. On August 22, 1999, a 12-year-old boy fell to his death after slipping through a harness during a 129-ft free fall on the Drop Zone Stunt Tower ride at Paramount's Great America theme park in Santa Clara, CA. On August 23, 1999, a 20-year-old man fell to his death from the Shockwave stand-up-style roller coaster at Paramount's Kings Dominion theme park in Doswell, VA. This particular roller coaster reaches a height of 95 ft and maximum speeds of 50 mph. Finally, on August 28, 1999, a 39-year-old woman and her 8-year-old daughter were killed when their roller coaster car slid backward down a 30-ft ascent and crashed into another car on the Wild Wonder ride at Gillian's Wonderland Pier in Ocean City, NJ.[4]

Injuries and deaths in amusement parks are not restricted to roller coaster style rides. For example, a 21-year-old man was recently killed on a reverse-bungee catapult ride called the Rocket Launcher in Ontario, Canada. The ride consists of 2 steel towers with a bungee cord connected to each. The cords are stretched toward the ground, where they are attached to the rider's safety harness and then released, catapulting the rider at high speeds into the air. Before the victim was launched into the air he was told by the "jumpmaster" to "hold out his arms and fly like

Table 1.
Roller coaster historical timeline.[1,2]

Time	Place	Description
15th and 16th century	Russia	Large blocks of ice used as sleds down 70-ft hills of ice.
1784	St. Petersburg, Russia	First wheeled roller coaster.
1804	Paris, France	First roller coaster to be built in Paris; called *montagne russe* (Russian mountain), in honor of its origin.
1817	Paris, France	First roller coaster with wheels that locked onto a track.
1846	Paris, France	First loop roller coaster, called "centrifugal railway," was tested with sandbags, monkeys, flowers, eggs, and glasses of water before humans beings were allowed to ride.
1884	Coney Island, NY	First American-built roller coaster, the Gravity Pleasure Switchback Railway, has two 40-ft towers with a track in between. It cost US$1,600 to build and reached a top speed of 6 mph; at 5 cents a ride, the investment paid for itself in 3 weeks.
1920s	—	Golden age of roller coasters; by 1929, there were 1,500 roller coasters worldwide.
1927	Coney Island, NY	The Cyclone reaches a high speed and has an 85-ft plunge and 60-degree angles. It is "industry standard" to this day.
1930s to 1940s	—	Great Depression and World War II lead to a decrease in the number of roller coasters to <200 worldwide.
1950s	United States	Walt Disney redefines the theme park industry; a new enthusiasm for coasters develops.
1984	Cincinnati, OH Williamsburg, VA	Advent of first successful stand-up coaster at Paramount's Kings Island and first successful suspended coaster at Busch Gardens, Williamsburg.
1992	Chicago, IL	First successful inverted coaster introduced at Six Flags Great America.
1997	Los Angeles, CA	Superman the Escape at Six Flags Magic Mountain exceeds 100 mph.

Table 2.
Roller coaster records 2001.

Roller Coaster	Park	Speed, Height, Drop, or G Force
Fastest roller coasters[3]		
Tower of Terror	Dreamworld, Coomera, Queensland, Australia	100 mph
Superman, The Escape	Six Flags Magic Mountain, Los Angeles, CA	100 mph
Steel Dragon 2000	Nagashima Spa Land, Nagashima, Japan	95 mph
Millennium Force	Cedar Point, Sandusky, OH	93 mph
Goliath	Six Flags Magic Mountain, Los Angeles, CA	85 mph
Tallest roller coasters[3]		
Superman, The Escape	Six Flags Magic Mountain, Los Angeles, CA	415 ft
Tower of Terror	Dreamworld, Coomera, Queensland, Australia	377 ft
Steel Dragon 2000	Nagashima Spa Land, Nagashima, Japan	318 ft
Millennium Force	Cedar Point, Sandusky, OH	310 ft
Fujiyama	Fujikyu Highland Park, Fujiyoshida-shi, Japan	259 ft
Greatest drop[3]		
Tower of Terror	Dreamworld, Coomera, Queensland, Australia	328 ft
Superman, The Escape	Six Flags Magic Mountain, Los Angeles, CA	328 ft
Millennium Force	Cedar Point, Sandusky, OH	300 ft
Goliath	Six Flags Magic Mountain, Los Angeles, CA	255 ft
Fujiyama	Fujikyu Highland Park, Fujiyoshida-shi, Japan	229 ft
Greatest G-forces[4]		
Taz's Texas Tornado	Six Flags AstroWorld, Houston, TX	6.5
Runaway Mountain	Six Flags Over Texas, Arlington, TX	5.2
Rock 'n' Roll Coaster	Disney MGM Studios, Orlando, FL	5
Two Face: The Flip Side	Six Flags America, Largo, MD	5
Face/Off	Paramount's Kings Island, Cincinnati, OH	5
Batman and Robin	Six Flags Great Adventure, Jackson, NJ	5
Invertigo	Paramount's Great America, Santa Clara, CA	5

Superman." His harness became disengaged, and he launched 100 feet into the air, landing on pavement.[4]

A *Journal of the American Medical Association* article in 1985[5] reported the death of a 14-year-old boy at a waterslide theme park in Utah. The boy was dangling from the side of a waterslide collecting pool when he was sucked into an underwater pipe (12.5 inches in diameter) that pumped water back up to the top of the slides. He traveled underwater 93 ft before becoming lodged in a 90-degree vertical bend in the pipe within the pump house. He was located after 15 minutes, but resuscitation efforts failed.

In this article, we review reports of amusement park injuries and fatalities that have been published in the medical literature. We also review amusement park injury and fatality data collected by the Consumer Product Safety Commission (CPSC). Finally, we review literature on the physics and the physiologic effects of roller coasters that may predispose healthy individuals to injury and make recommendations.

INJURIES IN THE MEDICAL LITERATURE

A MEDLINE search of the medical literature with no limitations between 1966 and the second week of August 2001 revealed numerous amusement park injuries. These include corneal foreign bodies from bumper car collisions,[6,7] a pneumothorax resulting from "reversed" bungee jumping,[8] a report of "roller coaster glaucoma" in a patient with Marfan's syndrome,[9] peritoneal dialysis catheter displacement after a roller coaster ride,[10] and lately, more frequent reports of neurologic complications after exposure to the G forces of roller coasters.

The January 2000 issue of *Neurology*[11] published a case report that was widely publicized in the media and cited by legislators fighting for regulation of the amusement park industry. The article described a 24-year-old Japanese woman who developed a headache on the way home from Fujikyu Highland Park in Japan. She had ridden 3 different roller coasters, each twice. These included the fifth-tallest roller coaster in the world, the $20 million Fujiyama. This particular coaster is 259-ft tall, has a 229-ft drop, and reaches speeds in excess of 81 mph. The patient's headache lasted 4 days, and she was initially diagnosed as having tension headaches. Four months later a magnetic resonance imaging scan revealed bilateral chronic subdural hematomas. This report referred to 3 previously published cases of subdural hematomas related to roller coaster rides and suggested an association.[11]

The authors commented that roller coaster rides create "up-and-down, to-and-fro, and rotatory acceleration, which produce tensile and shearing stresses." This could lead to tearing of the bridging veins and subsequent subdural hemorrhage. They further suggested that managers of amusement parks, builders, designers, and passengers should be aware that giant roller coasters can cause subdural hematomas in healthy individuals.[11] We found a total of 16 case reports of neurologic injury in the medical literature since 1979, with the majority of events occurring since 1990. Table 3 provides a summary of these reports.[11-23]

CPSC DATA

In July 2000, the CPSC issued a report on amusement park injuries, using emergency department reports compiled between 1993 and 1999. The data were collected from the 100 EDs in the United States that participate in the National Electronic Injury Surveillance System (NEISS). These 100 hospitals represent a stratified sample of the 5,388 US acute care hospitals with EDs and 6 or more inpatient beds. There are 5 strata in NEISS, 4 of which are stratified on the basis of annual ED visits (small, medium, large, and very large). The fifth stratum consists of children's hospitals.[24]

EDs participating in NEISS assigned a specific code to all cases of amusement park–related trauma treated at their institution. The data from these 100 EDs were then extrapolated to produce national estimates of injuries, with subsequently large confidence intervals (CIs).

Fatality data were obtained by searching various CPSC files, including death certificate files, the injury or potential injury incident file, and the NEISS file. "Capture-recapture" analyses were conducted on these files to derive fatality estimates for the years 1987 through 1999.

On the basis of this analysis, the CPSC estimated that there were 10,380±5,560 ED-treated injuries during 1999 (95% CI). This represents an increase from the 7,700±3,980 estimated injuries that occurred in 1993.[24] Seventy percent of the injuries in 1999 occurred at "fixed-site" amusement parks such as Disney World, Six Flags, and Universal Studios. Thirty percent of injuries in 1999 occurred at mobile (traveling) amusement parks. These data produce an estimated rate of 23.5 injuries per million attendees at fixed-site parks in 1999 (Table 4). Because annual attendance data are not reported for mobile amusement parks, it is impossible to generate an estimate of injuries per million visits to these facilities.

In its report, the CPSC noted a marginally significant increasing trend in fixed-site and total injuries between 1993 and 1999 ($P<.07$). However, their data did reveal a sharp increase in fixed-park injuries beginning in 1997.

The overall increase in injury rates from 1996 to 1999 was statistically significant (Kendall's τ 1-tailed test, P=.04). Reports of fixed-site amusement park injuries increased by 95% between 1996 and 1999, whereas attendance at these parks increased by only 6.5%.[24]

In July 2000, the CPSC issued a second report that analyzed amusement park fatality data collected between 1987 and 1999. The documented number of traumatic, nonoccupational fatalities during this time frame was 49, or 3.8 fatalities per year during the reporting period. During the 1990s, there were 21 documented deaths at fixed-site amusement parks and 7 deaths at mobile parks. The number of fixed-site fatalities in 1999 was 6; however, the exact total was still pending at the time of data release (Table 5). From 1993 through 1999, there was an upward trend in both fixed-site and total fatalities that did not achieve statistical significance (P=.08 by an exact Kendall's τ 1-tailed test).[24]

Of the 49 documented fatalities from 1987 to 1998, 12 occurred on roller coasters. Water rides were the second most common cause of fatalities, with 5 (Table 6). The states with the most amusement park fatalities were California and New Jersey, each with 6 deaths between 1987 and 1998. Injury rates by ride type and state were not provided.

There are important limitations to the CPSC reports. The CPSC itself noted that it would be difficult to conclude from these data that mobile parks are safer than fixed-site parks because accurate attendance counts at mobile parks are not available. If the attendance and number of rides per patron were known for both fixed-site and mobile parks, one could calculate the rate of injuries

Table 3.
Amusement park injuries cited in the medical literature.

Year	Country	Age/Sex	Pathology	Manifestations	Outcome	Journal	Author
1979	United States	13/F	Carotid thrombosis	Headache, right hemiparesis, aphasia	Occasional expressive aphasia	*JAMA*	Scheer and Carlin[12]
1991	United States	32/F	Subarachnoid hemorrhage and cerebral artery aneurysm	Headache, loss of consciousness	Full recovery	*J Neurosurg*	Senegor[13]
1994	Canada	26/M	Subdural hematoma	Headache, nausea, vomiting	Full recovery	*J Trauma*	Fernandes and Daya[14]
1995	France	53/F	Internal carotid artery dissection	Pain behind eye	Full recovery	*Presse Med*	Kettaneh et al[15]
1995	Canada	64/M	Subdural hematoma	Headaches	Full recovery	*N Engl J Med*	Bo-Abbas and Bolton[16]
1995	France	31/F	Vertebral artery dissection	Vertigo, week of neck pain/headaches	Full recovery	*Lancet*	Biousse et al[17]
1996	France	29/F	Internal carotid artery dissection	Headaches, hemiplegia, aphasia	Remained aphasic, hemiplegic	*Presse Med*	Kettaneh et al[15]
1996	United States	39/F	Traumatic thoracic cerebrospinal fluid leak with intracranial hypotension	Severe headache, nausea, photophobia	Full recovery	*Lancet*	Schievink et al[18]
1997	France	23/M	Syringomyelia, brain stem dysfunction	Ataxia, neck pain, brain stem dysfunction	Mild dysphagia, left hand ataxia	*Neurology*	Kettaneh et al[19]
1997	France	29/F	Vertebral artery dissection	Headaches, neck pain, cerebellar infarction	Full recovery	*Rev Med Interne*	Gadenne et al[20]
1997	United States	77/M	Subdural hematoma with midline shift	Nausea, vomiting, headache, dysarthria	Died 13 days after ride	*Am J Med*	Snyder et al[21]
1998	United States	37/F	Brown-Sequard syndrome, meningioma causing severe cord compression	Neck pain, numbness, altered temperature sensation	Mild residual spinothalamic deficit	*Lancet*	Bateman and Pople[22]
1998	France	31/M	Internal carotid artery dissection	Aphasia, convulsions, hemiplegia	Remained aphasic, hemiplegic	*Presse Med*	Kettaneh et al[15]
1998	France	35/F	Internal carotid artery dissection	Neck pain, headaches	Full recovery	*Presse Med*	Kettaneh et al[15]
1999	Japan	24/F	Chronic subdural hematomas	Headaches	Full recovery	*Neurology*	Fukutake et al[11]
2000	Italy	47/M	Intraparenchymal cerebral hemorrhage, subarachnoid hemorrhage	Headache, nausea, vomiting	Full recovery	*JAMA*	Nencini et al[23]

and fatalities per ride and type of facility. The proximity of the participating EDs to either a mobile or fixed-site amusement park is an important limiting factor in the data collection. If the participating EDs in NEISS were not found in geographic proximity to amusement parks, the CPSC data would significantly underestimate reported injuries. Furthermore, the CPSC report did not distinguish reports of minor trauma, such as ankle sprains or simple lacerations, from major trauma, such as a traumatic brain injury, in their statistics.

The CPSC did note in their 1998 report that only 0.8% of amusement park injuries required hospitalization.[25] This compares with an overall hospitalization rate across all product-related injuries in the CPSC's database of approximately 4% in recent years. Assuming this 0.8% hospitalization rate remained the same in 1999, this would represent 58 hospitalizations out of 7,260 fixed-site park–related injuries. The amusement park industry estimates that visitors take approximately 900 million rides per year. If this is true, it suggests that the risk of being injured severely enough to require medical attention on an amusement park ride in 1999 was 1 in 124,000 rides. The risk of injury requiring hospitalization was greater than 1 in 15 million rides. The risk of being fatally injured was 1 in 150 million rides (6 total deaths in 1999).

PHYSIOLOGIC EFFECTS OF ROLLER COASTERS

Currently, industry officials and legislators are debating the physiologic safety of roller coaster rides. Some government officials and safety advocates believe that new technological advances and competition within the amusement industry have led to dangerously high G forces that may produce bodily harm. Unfortunately, few medical researchers have studied the specific physiologic effects of roller coaster rides on the human body. In addition, lack of G-force studies directed specifically at roller coasters requires extrapolation of Navy and Air Force centrifuge data, which require careful interpretation.

A study by Pringle et al[26] looked at the physiologic heart rate response to riding on a roller coaster. Thirteen healthy participants with portable cardiac monitors were subjected to a double-loop corkscrew roller coaster with 3 Gs of acceleration and speeds greater than 40 mph for 94 seconds. The most striking finding to the researchers was the rate of onset of tachycardia. All participants reached their maximum heart rate within 8 seconds. The

Table 4.
Estimated amusement ride injuries by year and site of ride.[24]

Year	Facility Type: Fixed	Facility Type: Mobile	Total No. of Injuries	Park Attendance (Millions)	Injury Rate per Million Rides*
1999	7,260	3,120	10,380	309	23.5
1998	6,500	2,870	9,370	300	21.6
1997	5,460	2,580	8,050	300	18.2
1996	3,720	2,930	6,650	290	12.8
1995	4,290	3,260	7,540	280	15.3
1994	3,790	2,970	6,760	267	14.2
1993	4,830	2,880	7,700	275	17.5

*Injury rates apply to fixed-site injuries.

Table 5.
Amusement ride fatalities by year and ride site.[24]

Year	Fixed	Mobile	Unknown	Total
1999	6	0	0	6
1998	3	2	2	7
1997	1	0	3	4
1996	2	1	0	3
1995	3	1	0	4
1994	2	0	0	2
1993	1	1	2	4
1992	0	2	0	2
1991	3	0	0	3
1990	0	0	0	0
1989	3	0	0	3
1988	2	1	4	7
1987	4	0	0	4

Table 6.
Amusement ride fatalities from 1987 to 1999 by ride type and mobility.[24]

Ride	Facility Type: Fixed	Facility Type: Mobile	Facility Type: Undetermined	Total
Roller coaster	12	0	3	15
Whirling	2	4	4	10
Water	5	0	0	5
Train	2	1	0	3
Ferris wheel	2	0	0	2
Sleigh	1	0	0	1
Unknown	6	3	4	13
Total	30	8	11	49

mean heart rate increase was from 70 beats/min to 154 beats/min. No ventricular dysrhythmias or ST depression were detected. Comparing a roller coaster ride with a cardiac stress test, the researchers concluded that a rapid increase in heart rate and thus myocardial oxygen demand could place individuals with underlying ischemic heart disease at risk for a cardiac event.[26]

A "G" is a unitless measure of the acceleration of an object divided by the acceleration caused by gravity. Neglecting air resistance, Earth's gravitational pull causes free-falling objects to change their speeds by a constant 9.81 m/s^2 (32 ft/s^2). Dividing acceleration (calculated as change of velocity divided by time) by this constant equals the number of Gs.[27]

On the basis of medical reports of neurologic injuries on roller coasters, some legislators have proposed limiting the G-force levels of roller coasters to less than 4 Gs. Germany has adopted similar legislation, limiting their roller coasters to 5 Gs or less.[28] There are now more than 18 roller coasters in the United States that produce G forces in excess of 4.0 Gs, including Taz's Texas Tornado, which boasts 6.5 Gs (Table 2).[4] For comparison, the National Aeronautics and Space Administration (NASA) reports that astronauts on the space shuttle, which reaches speeds of 17,440 mph, experience maximum launch and reentry G forces of less than 4 Gs.[29]

The most comprehensive studies on human physiologic changes during high G-force exposures have occurred in space and aviation research. It is important to note that the majority of these studies have focused on more sustained periods of exposure to high G forces in centrifuges, rather than the short, intermittent exposure associated with roller coasters.

Researchers have studied the loss of consciousness induced by sustained G force, termed G-LOC. High hydrostatic pressures caused by sustained G forces cause a decrease in cerebral blood flow, leading to loss of consciousness. This is first preceded by a decrease in perfusion of the peripheral retina causing a "grayout." A "grayout" consists of loss of peripheral and then color vision. When the G forces increase further, perfusion of the central retina ceases, leading to a "blackout." G-LOC follows a blackout by approximately 0.8 Gs. G-LOC has been associated with confusion, amnesia, and seizures.[27]

In 1954, the US Navy studied 1,000 participants in its 2 centrifuges and found that the mean G associated with G-LOC was 5.4±0.9, with a range of 3.0 to 8.4 Gs.[30] Another study by the Navy in 1954 found that the time required to produce loss of consciousness at high Gs was a constant 4.2 seconds, independent of the G level (>3 Gs).[31] Current US Air Force research has expanded on these data and defines G-force tolerance in terms of the rate of acceleration, whether it is gradual (0.1 G/s), rapid (1 G/s), or very high (6 G/s). At a rate of 1 G/s, loss of consciousness occurs at an average of 5.4 Gs, with a range of 3.0 to 8.4 Gs.[27] Currently, there are insufficient data as to the exact time period over which roller coasters apply and sustain their G forces. The rarity of loss of consciousness on roller coasters suggests that the duration of applied G force on roller coasters is less than the 4.2-second threshold identified by Navy data.

A study by Allen et al[32] looked at the G forces experienced by the human head in everyday life. Each participant in their study was fitted with a helmet containing accelerometers that measured head motion in 3 dimensions. A computer then calculated the G-force vector. The authors calculated a sneeze to induce a force of 2.9 Gs. A cough was 3.5 Gs. A friendly slap on the back was 4.1 Gs. Plopping down into a comfortable chair was calculated as 10.1 Gs. The time over which this force lasted was similar in all events, with a mean time of 0.19 seconds.[32] This paper suggests that G forces up to 10 Gs applied to a human being for a fraction of a second do not result in loss of consciousness or serious injury.

The high G forces created by current roller coasters may not last long enough to disturb cerebral blood flow to the point of loss of consciousness. This does not mean, however, that the effects of brief, high G forces on the brain are benign. As already noted, case reports have demonstrated subdural hematomas, internal carotid and vertebral artery dissections, and subarachnoid hemorrhage in association with roller coaster–generated G forces, but no research has determined the human G-force threshold for these injuries. The absolute strength (total Gs), the duration of G force, and the rate of intensification of G force are all important variables. It is certainly possible that lateral G forces, rotational acceleration, abrupt directional changes, and predisposing anatomic factors play an important role in these types of injuries as well.

The mechanism of subdural hematoma formation has been well established. The meningeal layers (dura mater, arachnoid membrane, and pia mater) appear to be closely attached, and there is no evidence of a potential space between the inner dural border cell layer and the outer arachnoid cell layer. Subdural hematomas result from disruptive forces that split open the inherently weak cell plane that forms the dural border. Anterior-posterior forces are more frequently to blame, because the falx cerebri appears to afford some protection against lateral forces.[33] Rupture of bridging veins that connect the pia and dura mater or tearing of the small cortical arterial vessels during these applied forces results in the associated hemorrhage.[34]

Bridging veins are at particular risk of rupture because the subdural portions of the veins have relatively thin walls and lack outer reinforcement in comparison with the subarachnoid portion of these veins.[35] The forces that tear these veins can be direct or indirect and usually involve acceleration, deceleration, or both, such as from a motor vehicle crash or fall. These produce short duration, high strain loading on the brain. The risk of rupture of bridging veins is probably related to the magnitude, rate of onset, and duration of acceleration.[36]

Authors familiar with amusement ride trauma have speculated that the forces produced by roller coasters are substantial enough to lead to serious injury. Bo-Abbas and Bolton[16] commented that roller coaster rides induce marked rotatory and other positional changes in a deformable brain that is moving within a rigid skull. Tensile and shearing forces may be severe enough to rupture cortical veins leading to subdural hematoma. In their report, the authors compared this type of scenario with what occurs in the "shaken baby" syndrome.[16] Fernandes and Daya[14] also stated that, in the absence of any other predisposing factors, the acceleration forces associated with roller coaster rides can cause the tearing of bridging veins, resulting in subdural hemorrhage. Biousse et al[17] observed that carotid and vertebral artery dissections are often associated with indirect trauma or torsion of the neck. The acceleration and abrupt changes of direction on a roller coaster may induce uncontrolled rotation of the head with stretching of the cervical vessels and aorta similar to that observed with acute deceleration in a motor vehicle crash. Sturzenegger[37] reported that "trivial" trauma was to blame in 40% of internal carotid artery dissections, including sport and fitness activities, chiropractic manipulation, violent coughing or nose blowing, and rapid head turning.

REGULATORY OVERSIGHT

Current federal law subjects mobile amusement parks and carnivals to CPSC investigations. Jurisdiction over mobile parks was granted in July 1981. The CPSC was given the authority to investigate accidents, develop and enforce action plans to correct defects, and act as a national clearinghouse for accident and defect data. Fixed-site parks were to be included in this legislation but, after successful legal challenges from owners of large amusement parks, a "roller coaster loophole" was created. Large fixed-site parks were exempt from reporting injuries or fatalities to the CPSC. This loophole allowed states to decide whether or not to regulate and monitor large parks.[28]

Currently in the United States, 9 states (Alabama, Arizona, Kansas, Mississippi, Missouri, Montana, North Dakota, South Dakota, and Utah) and the District of Columbia have no regulatory laws governing fixed-site rides. Other states, like Florida (the home of Disney World, Sea World, and Universal Studios), have laws that exempt any park owned by a company with more than 1,000 employees from state inspections, injury reporting, or accident investigations.[28]

RECOMMENDATIONS

Although the current risk of injury, hospitalization, and death on amusement rides is extremely low, health care providers should be aware of a worrisome trend in the number and rate of amusement park injuries. CPSC statistics suggest that a statistically significant increase in amusement park ride injuries occurred between 1996 and 1999. Because of weak state oversight and the "roller coaster loophole," the true number of amusement park injuries is probably much higher than that currently reported.

There are several recent medical case reports of apparently healthy individuals suffering neurologic injury from high-speed, high–G-force rides. Although data exist as to the threshold of G force needed to produce loss of consciousness in a controlled centrifuge, there is little or no data on the neurologic effects of intermediate duration (ie, 1 to 4 seconds) G forces combined with rapid directional changes. Several authors have suggested that the giant roller coasters now being introduced may be capable of generating G forces sufficient to cause subdural hematomas and other serious neurologic injuries in an unknown percentage of riders.

Advances in technology are leading to ever faster, more thrilling rides as parks compete to attract patrons. There may come a point when roller coaster G forces reach or exceed the human body's threshold of tolerance. If and when this happens, significant increases in head, neck, and back trauma will occur. To prevent this from happening, medical researchers and roller coaster engineers should work together to define the upper limits of tolerance for riders, with an acceptable margin of safety.

The public may benefit from a more accurate and timely database of injury reports and investigations. Riders should be aware that, although the current risk of amusement park injury is very low, injuries and fatalities can occur. On the basis of our review, we believe that emergency physicians should consider amusement park rides a possible cause of unexplained neurologic events in healthy patients, otherwise this cause may be overlooked.

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